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REINFORCED EARTH

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REINFORCED EARTH

by

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ABSTRACT

This paper describes the principles and uses of reinforced earth technology with particular emphasis on applications relating to the mining industry.

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TERRE RENFORCÉE

par

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RÉSUMÉ

Le présent document décrit les principes et les utilisations de la technologie relative à la terre renforcée en accordant une importance particulière aux applications qui se rapportent à l'industrie minière.

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1.0 INTRODUCTION

In 1958 Henri Vidal was on vacation in the Baleares Islands in the Mediterranean Sea. While on the beach he experimented building piles of sand and noted that the angle of natural repose was always the same. However, he discovered that if layers of pine needles were added to the sand piles the angle of repose became steeper. Realizing that no one had yet investigated the reinforcement of sand with flexible strips, Henri experimented in private and concluded that the reinforcement of earth with flexible strips provided a very economical alternative to some of the normal methods of civil engineering construction. He applied for, and was granted patent rights in most of the countries in the world. Since then thousands of construction projects using reinforced earth technology have been completed by the "Reinforced Earth and La Terra Armee group of companies" who hold licenses under the patents of Henri Vidal. Many of these projects have been constructed for mining operations. This paper examines the uses to which reinforced earth technology has been applied in mining operations and discusses the principals governing this technology.

2.0 THEORY

To obtain patent rights for the reinforced earth technology, Henri Vidal had to demonstrate that the governing principals of this methods were unlike those of other civil engineering practices. For instance, one of the essential characteristics of reinforced earth is that it is only made with two types of elements: grains and reinforcement without any necessity of a glue, like the cement of reinforced concrete or the clay of adobe walls. Also, Henri had to show that it was not an anchorage technique and that the reinforcements were flexible and could follow the movements of the earth.

The essential principal underlying reinforced earth is that friction between the grains and the reinforcement prevents the grains from moving in a horizontal direction. This frictional force increases as a vertical load is applied to the grains. Consequently, as a load is applied to the pile of reinforced grains the frictional forces preventing collapse of the pile also increases. This effect is directly analogous to an increasing confining stress in triaxial loading conditions. As the confining stress increases the ability of a material to resist vertical loading without failure also increases.

The major uses of reinforced earth includes the construction of embankments, dams and retaining walls. In these situations the reinforcing strips are connected to facing elements at the boundaries. These facing elements are typically concrete slabs that slot together. It is easy to make the assumption that these facing elements prevent the soil mass from collapsing and are therefore the major element of reinforcement. This is not true. The facing elements merely prevent small portions of earth from falling off the sides and they also prevent erosion. It is in fact the reinforcing strips that provide stability to the soil mass by confining soil movement through the tension generated in the strips by friction. Theoretically the facing slabs could be removed without causing any immediate instability.

Analytical methods used to describe the mechanisms of earth reinforcement are numerous and are a source of much debate as to which describe the mechanisms the most accurately. It is generally agreed among researchers in this field that many of the basic fundamental details still remain to be worked out andd although conceptually simple the behaviour of reinforced earth is actually very complex. Hence it is likely that many years will pass before the basis mechanisms are established to everyones satisfaction. The success of reinforced earth designs can be attributed mainly to experience and many field trials.

3.0 MATERIALS USED

The selection of the material for the reinforcement strips is dependent on the ability of the material to resist corrosion and maintain its properties while buried in earth for a long period of time. Plastics and fiberglass were experimented with at an early stage but were discarded since their stability with age was questionable. Initially the material of choice was galvanized steel because its long term behaviour was well known. Stainless stell and aluminum alloys were also used in some structures but it became evident that surface corrosion and penetration of these materials could occur. This was due to the fact that these materials are normally protected by a thin oxidized layer but in soil, under certain conditions, this layer could be destroyed and trigger galvanic corrosion that could propagate at great speed. With mild galvanized steel however, the corrosion

is always slow, uniform and predictable and has been well studied before reinforced earth technology evolved.

The facing material that is attached to the strips of reinforcement are designed to prevent loose soil between the strips from spalling from the wall of the slope. As such they are not under any great stress and merely control a very localized problem. Sheet steel has been used with success although the most popular material, which has been used for over 90% of structures built to date, is precast concrete panels which interlock but have flexible joints to allow for any movement without damage. The reason for this preference is that they are more asthetically appealing and in some structures, such as coal storage facilities, it is important to have a flat face that is very resistant to abrasion.

4.0 APPLICATION OF REINFORCED EARTH TO THE MINING INDUSTRY

4.1 Coal Storage Facilities

Reinforced earth has recently found favor as a construction method for coal storage facilities of high capacity. These may take the form of slot type storage, such as the 100,000 tonne facility at the Cordero Mine in the United States, or in the form of Glory holes such as at the Obed Marsh Ming in Alberta. An innovative feature of the Obed Marsh glory hole is the roof structure, which is a reinforced, post-tensioned, free standing dome that spans 57.5m and yet is only 90mm thick.

since 1977 reinforced earth has been used to construct fourteen U.S. coal storage facilities representing 732,000 tonnes of live storage. The reasons for selecting this method of construction are that they are more economical and predictable in cost than with other methods and are also significantly quicker to construct.

4.2 Other uses

Other applications of reinforced earth in the mining industry include headwalls or tip walls for coal crushers and screening plants. The reinforced earth wall can support loaded haulage vehicles to within a few feet of the verticle surface allowing the trucks to tip directly into hoppers or crushers. These structures have no height limitation and can undergo substantial settlement without loss of function or structural

distress. Also, these structures are easy and quick to build and are claimed to cost 30 - 40% less than alternatives.

Reinforced earth also can be used for the construction of sedimentation basins and dams.

5.0 FUTURE TRENDS

Research is still continuing into the use of synthetic reinforcing material in the hope of discovering a suitable non-corrodable medium. Such materials include resin bonded fibreglass, encapsulated polyester yarn, plastic meshes (geogrids) and a wide range of fabrics (geotextiles). The difficulty in using these materials for earth reinforced structures is due to the fact that the materials most resistant to degradation are often associated with high creep coefficients. Although a proportion of creep deformation may be acceptable in some structures, it is important to ensure long term strength.

One area where long term strength is not essential is in the reinforcement of temporary mine haulage routes. In this instance relatively high rates of creep may be tolerable, especially if only separation of the construction materials is required. Geotextiles are likely to be the most economic material for this application although plastic geogrids which have higher strength and lower creep coefficients may also be of use. In the field of earth reinforced structures, geogrids would seem to be the most likely candidates to replace galvanized steep grips.